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Land Use Experience in Southern Great Plains

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INTRODUCTION

The abandonment of cultivated land became a serious matter during the 1930's in wind-eroded parts of the southern Great Plains. It raised a question about the suitability of High Plains land for cultivation.

Then, a reverse movement took place during the 1940's. Expanding crop production caused by the war market and favorable weather has since overrun the previous frontiers of crop production in some places. The scarcity of choice new land in the old established dry-farming areas of the Plains led to two new and different fields of attempted marginal land development.

First, in the semiarid belt (rainfall 17 to 25 inches) farmers have resorted to the cultivation of the more sloping lands that break over into the drainage basins in order to gain more cropland. Second, in the arid borderlands (average annual rainfall less than 17 inches) they have ventured out onto shallow soils and loose sands not heretofore thought fit for cultivation.

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In view of these happenings attention has recently been focused on the old questions about land capability. The great need for land use guidance in the questionable areas has prompted the author to explore the experience of the past. What kinds of lands have been abandoned, and what has since happened to them become questions of importance to guide present and future action. How well the better lands stood up under cultivation through good times and bad times, and how soil erosion has affected crop yields also demand our attention. Finally, we need more facts about the nature and extent of erosion, and the practical ways of holding it in check under different soil and climatic conditions, to help us deal with the problems of marginal land use.

PLAN OF STUDY

To get these facts a study was undertaken of land use experience under average farm conditions. The starting point was a physical land survey made by the Arthur H. Joel party in 1936.[2] It covered 20 counties centering on the juncture of Colorado, Kansas, and Oklahoma. This mapping provided a record of the land use in effect at that time. In addition to descriptions of soils, slopes, and vegetation, this survey furnished a record of the nature and extent of soil erosion that had taken place before 1936.

At the time of the Joel survey, the land of the 20-county area was 40.5 percent under cultivation. Eight and one-half percent had been cultivated and abandoned while 51.0 percent remained in native sod.

In 1947 a repeat survey was made of the area. It was purposely confined to sample areas consisting of farming rather than ranching country. Without regard to erosion experience, these sample areas were plotted to cover the major dry-farming land types under average annual rainfalls ranging from 14.7 to 19.4 inches. The soils ranged from sands to clays, mostly lying on slopes of less than 2 percent, though a considerable sampling of B slopes (2 to 5 percent) was also obtained.

The 1947 survey covered 2,347,480 acres out of the 16,312,377 acres in the original survey. Only 16.1 percent of the land resurveyed was being used for pasture in 1947, although 51.0 percent was so used in the area as a whole at the time of the Joel survey. The location of sample areas is delineated within the Joel survey as shown in figure 1.

The physical land conditions mapped in 1936 included nine groups of soils separated on the basis of texture, structure, and depth, of which six are listed in table 1. Four slope ranges were separated as follows: A, 0 to 2 percent; B, 2 to 5 percent; C, 5 to 10 percent; and D, over 10 percent. Degrees of sheet and gully erosion by water and of removals and accumulations by wind were recorded. The land use existing at the time of mapping was broken down to include cultivated land, idle or abandoned land, five different types of native vegetation, and barren or nonagricultural lands.

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[2] Joel, A. H., SOIL CONSERVATION RECONNAISSANCE SURVEY OF THE SOUTHERN GREAT PLAINS WIND-EROSION AREA. U. S. Dept. Agr. Tech. Bul. 556, 68 pp., illus. 1937.

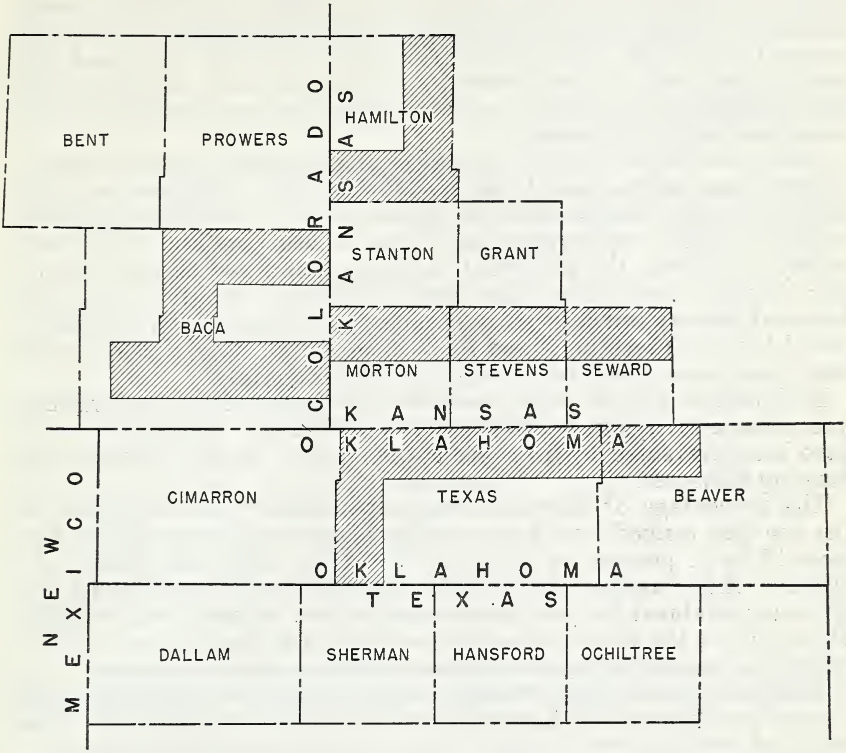

FIGURE 1.—Location of sample areas (shaded) as mapped in 1947.

The same legend was used in the repeat survey of 1947 and, in addition, three well-marked stages of natural revegetation on the abandoned tracts were mapped. This repeat survey gives a reasonably clear picture of what has happened to the lands previously abandoned, the conditions under which more abandonment has taken place, and what the erosion trends were during the 11-year period between surveys. Equally instructive is the inventory of new lands that have been broken out since 1941.

RATE OF ABANDONMENT AS A MEASURE OF CAPABILITY

The abandonment of cultivation in a field signifies the farmer's verdict of failure. Early in the study of abandonment it was seen that such idleness as existed in 1936 took in two kinds of failure, physical land failure, or failure of the farmer to continue operations because of financial distress or other causes.

What commonly happened on abandoned fields during the 1930's was the eventual stabilization of erosion conditions by natural vegetation; this natural stabilization usually was brought about by invasion of annual weeds and later by invasion of perennial grasses and other plants of a more permanent value. The rapidity with which weeds stabilized an area, however, varied greatly with the different soils and seasonal conditions. Frequently some soil removals continued for several years after abandonment, and in some cases accumulations kept building up. In other cases accumulations soon reached a maximum and began dispersing.

After the combination of high prices and favorable weather started in 1941, most of the abandoned land was quickly reclaimed and put back into crops, except where the blow-outs or accumulations were so severe that this was impractical. Thus, it was possible in the 1947 survey to separate the fields that had been abandoned because of erosion damage from those that were abandoned mainly because of financial distress and other causes than erosion damage. Where abandoned land was reclaimed and again made productive, it is assumed that abandonment was due mainly to financial distress.

It should be kept in mind, however, that some of the land failure was not necessarily due to low capability of the land. Some of it could have been prevented by a proper application of known conservation farming measures.

The percentage of plowed acreage abandoned from all causes at any one time ranged from 8 to 64 on hard lands at different places, but from 58 to 81 percent on the sandy row-crop lands under like conditions. After as much as possible of the formerly abandoned acreage was reclaimed for war production, it was evident that roughly 60 percent of the earlier abandonment had been due to financial depression, whereas 40 percent had been due to severe soil erosion.

Further proof of these findings resulted from the examination of erosion conditions on the lands that remained abandoned to 1947. The extent of erosion severe enough to force abandonment in the different soils groups is set forth in table 1.

A description of these soil groups and their distribution both as to zones of rainfall and slope classes follows:

Soil group 1: Deep dark-colored granular loams, silt loams, clay loams, silty clay loams, and some clays over deep cloddy, heavy clay subsoils, lighter in color than the topsoils.

These lands are typically A slope, and the decline in nitrogen and organic-matter content is comparatively gradual from the surface to depths of 4 to 5 feet. No group 1 soils were mapped west of the 16-inch rainfall line and none east of the High Plains in the areas of this study. No B slope lands of this group were found east of the 17-inch rainfall line where water erosion begins actively to offset deepening of the profile under sloping surfaces.

Soil group 2: Medium depth loams, silt loams, clay loams, and silty clay loams, with cloddy heavier upper subsoils over calcareous sandy clay and lighter textured lower subsoils.

The larger acreages of this soil group are found in the 14- to 17-inch rainfall zone, with minor areas, only, east of the High Plains. Areas of A and B slope are more evenly divided than in the case of the deep hard lands group.

Soil group 3: Shallow granular to cloddy loams, silt loams, clay loams, and silty clay loams, usually calcareous from the surface downward or at shallow depths.

Table 1.—*Percent of plowed acreage abandoned due to severe erosion in rainfall zones of the old dust bowl to 1947*

Soil group and slope class [1]	Where average annual rainfall was—		
	14 to 16 inches (arid)	16 to 18 inches (marginal)	18 to 20 inches (semiarid)
	Percent	*Percent*	*Percent*
1 A—Deep heavy-textured nearly level lands	--------	0. 6	0
2 A—Medium depth heavy-textured nearly level lands	13. 1	7. 5	0
3 A—Shallow heavy-textured nearly level lands	22. 1	14. 8	--------
4 A—Medium depth moderately sandy nearly level lands	19. 8	4. 0	. 6
5 A—Deep sandy nearly level lands	16. 3	12. 1	2. 8
1 B—Deep heavy-textured gently sloping lands	--------	. 8	--------
2 B—Medium depth heavy-textured gently sloping lands	13. 6	1. 2	--------
4 B—Shallow moderately sandy gently sloping lands	24. 2	11. 6	8. 9
5 B—Deep sandy gently sloping lands	24. 2	21. 3	13. 3
6 B—Deep loose sand, gently sloping sand hills	--------	18. 9	12. 2

[1] For description of soils by groups as used in this study see also Joel, A. H., SOIL CONSERVATION RECONNAISSANCE SURVEY OF THE SOUTHERN GREAT PLAINS WIND-EROSION AREA. U. S. Dept. Agr. Tech. Bul. 556, 68 pp., illus. 1937.

Only the A slopes, which represent a minor portion of the group acreage, have been extensively cultivated. Lands of this group are distributed throughout the rainfall zones, but have been tried out under cultivation principally in the areas of less than 17 inches annual rainfall.

Soil group 4: The heavier sandy loams, chiefly fine sandy loam, moderately deep on A slopes and shallow on B slopes, have been extensively cultivated in areas from 14 to 20 inches rainfall, with A and B slopes represented in all climatic zones.

Soil group 5: Loamy sands, fine sands, and light phases of the sandy loams and fine sandy loams, with somewhat heavier subsoils, sometimes of sandy clay.

A and B slopes are about equally represented in the arid and marginal zones, but B slopes predominate in areas of 19 inches or more annual rainfall.

Soil group 6: Fine sand, structureless, with loose open subsoils, found only in sand-hill topography, with B slopes or steeper.

These soils have been extensively cultivated only in areas of 17 inches annual rainfall or more.

To start with, the early settlers had some unique ideas about the choice of lands to be plowed. Then it took some kinds of land longer to wear out than others. Nevertheless, all the sample areas have been settled long enough for the abandonment stage to have been reached to some extent.

The durable quality of the deep, heavy-textured, nearly level lands is strongly evident from the data in table 1. The good behavior of all kinds of nearly level lands is evident in the semiarid belt, but all kinds, flat and sloping, heavy and light, have suffered serious rates of abandonment in the arid belt. Perhaps a measure of capability equally as good as abandonment, and one which can be pinned down to a certain period of time, would be the extent of severe erosion.

RATE OF EROSION AS A MEASURE OF CAPABILITY

Since rapid erosion has consistently led to land failure, the presence of an excessive rate of erosion removals indicates potential abandonment. The period 1936–47 must necessarily serve as our sample of weather and price conditions. Whether or not it presents a fair average it, at least, includes both good and bad seasons, high and low prices. The extremes were certainly accented by the coincidence of poor crops with low prices and of good crops with high prices.

The period 1936–41 began about the peak of the dust storms and marked their decline to a minimum. Beginning with 1942, wind-erosion control was practically automatic because with good seasons abundant regular crops left protective residue on the land.

This was a short period in which to find all the kinds of variations in conditions common to the area. Therefore, it was felt that any land type on which erosion advanced 2 degrees (from no erosion to moderate erosion, slight to severe, or moderate to very severe) or more during 11 such years was at once subject to suspicion. Examples are common of areas in which no erosion existed in 1936, moderate removals had occurred by 1947, and slight erosion noted in 1936 had become severe by 1947.

Thus actual abandonment and potential abandonment existed together on most of the soil-climatic combinations studied. Of course, if all the land that was destined for eventual abandonment had already been abandoned it would be necessary to look no farther for an index of durability under cultivation. But since varying degrees of abandonment exist side by side, it is necessary to take into account also the extent of a severe erosion rate leading toward abandonment in order to have comparable values.

These numerical values bring into sharp focus the relative durability of different soils. Four inches of topsoil removal may put a shallow soil completely out of business, whereas the same amount of removal does not reduce the productive potential of the deep soil proportionately. However, in many cases, practical experience has shown the difficulty of future erosion control to have been greatly increased by topsoil removals from deep soil.

Table 2 shows the percentages of plowed acreage that lost 25 to 75 percent of the surface soil by erosion removals in the period 1936–47. The exceptionally high rate of wind-erosion damage on soil group 5 A in the 16- to 18-inch rainfall zone appears to be due to a marked preference of farmers for the sandy loams of this soil group over the loamy sands as agricultural development progressed westward through this territory.

Extensive areas of loamy sands and fine sands occurring on A slopes encouraged undue exploitation of these soils in the older settled counties of the area studied. It is also considered likely that the long period of cultivation of the lands plowed prior to 1936 has played a part in the rapid rate of decline observed during the 1936–47 period.

The Colorado experiment station recognizes distinct and important differences in the capability of loamy sands and sandy loams, that were lumped together in soil group 5 of the Joel survey. The data of tables 1 and 2, as well as the conclusions arrived at in table 3, strongly indicate the necessity of breaking down this group for a further and more conclusive study.

The general likeness of the trends shown in tables 1 and 2 brings out the close relation of erosion and abandonment, in spite of the varying lengths of farm experience in the different areas.

TABLE 2.—*Percent of plowed acreage on which erosion removals advanced 2 degrees or more between 1936 and 1947*

Soil group [1] and slope class	Where average annual rainfall was—			Soil group [1] and slope class	Where average annual rainfall was—		
	14 to 16 inches (arid)	16 to 18 inches (marginal)	18 to 20 inches (semiarid)		14 to 16 inches (arid)	16 to 18 inches (marginal)	18 to 20 inches (semiarid)
	Percent	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*
1 A	-------	2.4	1.1	1 B	-------	14.1	-------
2 A	5.2	6.7	0	2 B	.9	16.0	-------
3 A	-------	20.8	-------	4 B	14.4	25.2	27.2
4 A	7.8	5.5	.4	5 B	9.1	23.4	2.4
5 A	8.6	12.9	1.1	6 B	-------	27.4	24.0

[1] See table 1 for key to land descriptions.

The combining of these two factors in one index number, shown in table 3, summarizes the effects of cultivation on the land under average farm conditions as far as the land use experience of the area has gone up to this time. In this table the soil groups are arranged as nearly as possible in the order of their capability. In the arid zone only soil groups 1 and 2, on A and B slopes are suited for any cultivation and they must be farmed with extreme care.

LAND-CAPABILITY CLASSES

In the land-capability classification of the Soil Conservation Service all land is divided into eight broad classes. The first three classes include land that can be plowed and cultivated regularly, without lasting damage, under good conservation treatment. Class I land needs little or no special care to keep it good. From every standpoint it is very good land. Class II land has physical features that limit land use slightly or impose moderate risks of erosion or other damage. In the southern Great Plains the limiting factors in land capability are chiefly climate, slope, depth of soil, and water-holding capacity. In the marginal rainfall zone of 16 to 18 inches only the deep, dark-

TABLE 3.—*Land capabilities indicated by land use experience in sample areas of the old dust bowl to 1947*

Soil groups and slope classes in order of average capability	Tillage hazards [1] by rainfall zones with corresponding land-capability classes						Average tillage-hazard rate for the whole area	
	14- to 16-inch zone (arid)		16- to 18-inch zone (marginal)		18- to 20-inch zone (semiarid)		In percent of loss	When soil group 1A=1.0
	Percent	*Class*	*Percent*	*Class*	*Percent*	*Class*	*Percent*	
1 A	[2] (4. 4)	--------	3. 0	II	1. 1	II	2. 8	1. 0
2 A	18. 3	IV	14. 0	IV	0	II	10. 8	3. 8
1 B	(13. 1)	--------	14. 9	IV	(9. 5)	III	12. 5	4. 5
2 B	14. 5	IV	17. 2	IV	(10. 9)	IV	14. 2	5. 1
4 A	27. 6	VI and VII	9. 5	III	1. 0	II	12. 7	4. 5
5 A	24. 9	VI and VII	25. 0	VI and VII	3. 9	II	17. 9	6. 4
3 A	22. 1	VI and VII	25. 6	VI and VII	(2. 5)	-------	16. 7	6. 0
5 B	33. 3	VI and VII	44. 7	VI and VII	15. 7	IV	31. 2	11. 1
4 B	38. 6	VI and VII	36. 8	VI and VII	36. 1	VI and VII	37. 2	13. 3
6 B	(40. 7)	VII	46. 1	VII	36. 2	VI and VII	41. 0	14. 6
Typical A-slope average	23. 6	--------	16. 1	-------	1. 6	-------	-------	4. 9
Typical B-slope average	35. 9	--------	40. 7	-------	25. 9	-------	-------	12. 2

[1] Tillage hazard is an index number representing the rate of soil damage under cultivation to date. It is obtained by adding the percent of abandonment due to erosion at any given time to the percent of potential abandonment indicated by an excessive rate of erosion existing at the same time.

[2] Interpolations were calculated where a sample was missing or inadequate. These are enclosed in parentheses. A land capability class has been assigned only where the particular soil group was common to the rainfall zone, otherwise the interpolated value is wholly theoretical.

colored hard lands meet the requirements for class II. From an all-round standpoint, class II land is good land that can be cultivated safely with easily applied special practices.

Class III land is severely limited by permanent physical features. It can be used regularly for crops under a good system of management but must have intensive treatments to overcome the natural limitations or to assure permanence of soil under existing natural hazards. From the all-round standpoint it is moderately good land.

Class IV land is very severely limited by permanent physical features. It can be used safely for certain limited forms of cropping but in this region is more safely used as grazing land.

Classes V, VI, VII, and VIII are not suited for cultivation. Class V land has few natural permanent limitations for grazing or forestry use. Class VI land can be used for at least one of these purposes, only moderate limitations being required because of land features. Class VII land is severely limited for these uses. Class VIII land is not suited for cultivation, grazing, or forestry. It may be useful for wildlife, recreation, or watershed purposes.

TRANSLATING LAND USE EXPERIENCE INTO CAPABILITY CLASSES

General observation in the arid and semiarid dry-farming areas impressed most observers with the idea that land capability depended both on the nature of the soil and on the climate. For example, it is usually granted that some middle-grade soils can be maintained under cultivation in areas of more than 17 inches of rainfall but not below that.

On the other hand, the task of keeping cultivated land productive is greater under more rainfall if the land is sloping. Thus the relation of rainfall to tillage hazard is complicated. The erosion records in the areas comprising this study show that 89 percent of the soil removals from A-slope lands has been due to wind action. Removals recorded on B slopes were due to the combined action of wind and water.

A surprising result of this study was its revelation of the fact that serious damage by water erosion extends throughout the semiarid belt. Lands sloping 2 to 5 percent suffered half as much from sheet erosion as from wind erosion even in the arid zone (14- to 16-inch rainfall). Under 16 to 18 inches of rainfall the water-erosion damage was 1½ times as much on lands with 2- to 5-percent slope as the wind-erosion damage and with 18 to 20 inches of rainfall 15 times as much. On nearly level lands (0- to 2-percent slopes) there was only slight water erosion in the 18- to 20-inch rainfall areas.

The importance of this water-erosion hazard is increasing with the breaking out of new lands on B slopes. Such lands undergo the greatest tillage hazard in the marginal zone where wind and water erosion overlap to create a double risk.

The lands with A slopes, which are not greatly affected by water erosion anywhere within the range of this study, have been subject to the greatest tillage hazards in the westward areas of least rainfall. The tillage hazard increased about 2.5 times in passing from A to B slopes on the same type of soil in the marginal rainfall zone of 16 to 18 inches. It was less on the arid side and much more on the semiarid side.

The foregoing illustrates the interaction of the varying factors responsible for the slow or fast wearing out of soils that were placed in cultivation in the southwestern High Plains. The selection of a breaking point where the index of tillage hazard warrants our drawing the line between the use of land for crops and for pasture is most important.

The rates at which different land types are being worn out and discarded for crop production constitute one of the factors involved. Actual measures of these rates have been made for the main land types of the areas under study. The practical possibilities of a conservation program to offset the losses that have been commonly experienced heretofore is another factor involved in the selection of a correct division point. The weight of this factor can be estimated from the results of evaluation studies.

EFFECTS OF SOIL-CONSERVING PRACTICES

Three features of the conservation program stand out as particularly useful in preventing unnecessary wear and tear on soils of the High Plains.

(1) Crop management in rotation or variable sequence to keep up organic matter and provide protective ground cover when it is needed most.

(2) Water-control measures, that have increased yields about one-third, reduced the frequency of complete failures where water conservation was needed, and reduced water erosion on sloping lands; in this connection, terracing is needed to offset water erosion on B slopes. The yield increase is not needed to keep the better class A slopes in cultivation but certainly is needed on B slopes to anchor the soil enough to keep it at home.

(3) The use of stubble-mulch tillage, which is very important in clinching the benefits of water and crop management.

Stubble mulching is more easily accomplished by adopting subsurface tillage practices that leave the durable residues of small grain and sorghum crops on the surface of the fields during the winter and spring windy seasons. Implements suitable for this purpose include both chisel and blade plows, chisel and sweep cultivators, rod weeders, rotary hoes, and various types of disk implements designed and operated for stirring rather than turning the topsoil. Tillage needs vary with the seasons, soil types, weed types, and different kinds of crops and crop sequences. For this reason, the selection of the right implement to fill the tillage needs requires a supply of different types of equipment. Stubble-mulch tillage has proved capable of delaying the loss of vegetative cover under protracted wind hazards and of protecting against washing while prolonging a favorable infiltration rate.

Some evidences of the effects of erosion-control demonstrations were found in the detailed erosion data of the sample areas. Severe erosion between 1936 and 1947 was consistently less in and around the Liberal, Kans., Springfield, Colo., and Guymon, Okla., demonstrations. Likewise, the plowing of low-capability lands has been less extensive in those vicinities.

On the other hand, the area as a whole showed no significant change in the relative amounts of erosion damages existing on the plowed lands between 1936 and 1947. Local gains in reducing wind-erosion hazards have been offset by the amount of low-grade land added to the cultivated acreage during the period. Likewise, the water-erosion hazard has been greatly increased by the extensive plowing of sloping new lands in certain areas.

On the best soil group to be found in this territory, the recorded tillage hazard has not exceeded 5 percent. It is quite plain that simple conservation practices were sufficient to overcome this mild rate of land failure and that the necessary practices can be applied rather easily. Therefore, all groups showing less than 5-percent loss of acreage up to 1947 were assigned to land-capacity class II (table 3).

Where the damage by erosion has induced or made ready for abandonment from 5 to 10 percent of the cultivated acreage, it was still considered practical to keep the lands permanently in crops, but the complex practices of a complete coordinated conservation plan would be needed to do so. Hence, these lands were placed in land-capability class III.

Where the tillage hazard totaled between 10 and 20 percent by 1947, the lands were placed in class IV, land suited for limited cultivation or for cultivation with extreme care. While it is recognized that such lands produce profitably during favorable rainfall periods, the damage has been so great when conditions were adverse that experience confirms the necessity of periodic retirement. In order to protect lands of this character adequately, the retirement must be timely and the maintenance of vegetative cover must be assured.

In the "Arid" column of table 3 (14- to 16-inch rainfall zone), it will be noted that no soil groups were found in which the tillage hazard had proved to be less than 14.5 percent. This would mean for the sample area in question that none of the lands were capable of being kept permanently in cultivation. While this classification (land-capability class IV) will, during favorable climatic periods, cause operators and technicians to feel the lands are not rated at their full capacity, it should be remembered that many of these same operators have previously passed through conditions under which they believed that their land had been overrated. This applies to medium-depth hard lands, both A and B slopes.

Based upon interpolation from adjacent areas, where deep hard-land soils were found, the chance of finding croplands suitable for permanent cultivation below an annual rainfall of 16 inches at the latitude represented by these studies would be confined to relatively small areas of deep hard lands which would theoretically be rated as land capability class III. Because such lands are scarce in the areas of scant rainfall, long and successful land use experience would be needed as yet to establish class III in this rainfall zone as a practical basis of conservation planning.

Classified in this manner, average class III lands are wearing out under existing practices 3 times as fast as average class II lands; the class IV lands 6 times as fast as class II. The actual class III land samples encountered in the field as listed in table 3 are wasting 4.2 times as fast as class II, while the land classed in the table as IV has been going 6.7 times as fast.

Efforts to keep in cultivation lands going to the bad at a faster rate than that have proved fruitless. Cultivating such lands even for a short time may cause severe and permanent damage to their productivity for grazing purposes. Such soils are the deep loose sands and the rolling, shallow, moderately sandy soils wherever found. Along with them are classed other sandy, shallow, or sloping lands that will not stand up with lesser amounts of rainfall.

In spite of the sorry record of these lands, 63,870 acres more of the same kinds have recently been put in cultivation in the sample areas under study.

Continued observation of the behavior of these border area soil groups, particularly under conservation practices, is recommended to soil conservationists in the field. While full confidence is felt in the capabilities already proved under agricultural conditions of the past half century, there always exists some uncertainty about the extremes of weather variations that should be expected in the future. There is no way of knowing whether we have already experienced the maximum severity of natural conditions or not.

COMPARISON OF SAMPLE AREAS WITH RESPECT TO TILLAGE HAZARD

If we accept the plowed land as we find it for the best of the cropland resources contained in each sample area, one area still might not be on a par with another because of different times of settling up. But since the estimation of potential abandonment tends to equalize the duration of the agricultural experience, a rough comparison of the tillage hazard by areas can be made. Table 4 shows that there is an average hazard of 24.9 percent in the arid zone. The marginal zone (16- to 18-inch rainfall) averaged 15.9 percent and the semiarid zone 10.8 percent.

TABLE 4.—*Average tillage hazard and relation of wind-erosion removals to accumulations on cultivated lands in sample areas in 1947*

Sample areas	Average annual rainfall	Average tillage hazard	Acres of blow-out to 1 acre of accumulation in— Hard-land areas	Acres of blow-out to 1 acre of accumulation in— Sandy-land areas
	Inches	*Percent*	*Acres*	*Acres*
West Baca County, Colo	14. 7	24. 9	10. 3	4. 8
East Baca County, Colo	16. 6	9. 3	38. 3	6. 8
Hamilton County, Kans	16. 9	13. 6	23. 8	2. 9
West Texas County, Okla	16. 9	16. 8	23. 1	3. 2
Morton County, Kans	17. 1	11. 9	13. 0	6. 8
Stevens County, Kans	17. 2	27. 5	3. 5	1. 3
East Texas County, Okla	17. 8	16. 2	13. 3	7. 6
Seward County, Kans	18. 9	15. 0	3. 0	3. 8
North Beaver County, Okla	19. 4	6. 6	--------	11. 2

In comparing the several adjacent sample areas, a predominating land type may strongly affect the average tillage hazard. The pattern of hard-land and sandy-land areas gives good chance to observe some general features of wind-erosion behavior. Table 4 gives a hint of what becomes of wind-blown soils.

Figure 2 is a generalized map showing areas where different land types predominate in the territory represented by this study.

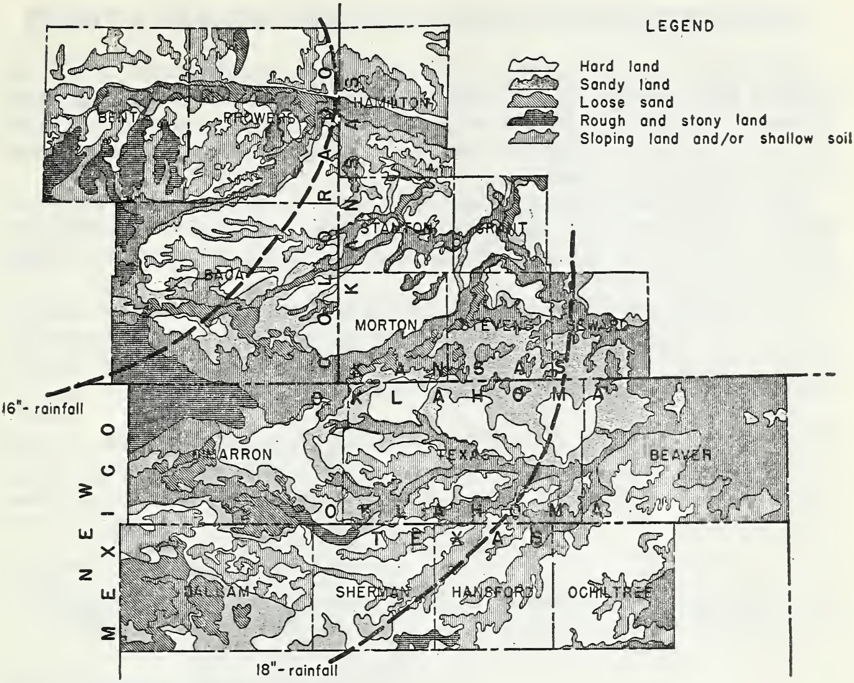

FIGURE 2.—Panhandle of Oklahoma and adjacent counties of Colorado, Kansas, and Texas.

On the west side of Baca County the farming communities are bounded on their windward sides by range country. The acres of blow-out per acre of accumulation were below the average for hard land, indicating a possible border effect. However, on the sandy land the proportions were average. From 3 to 6 acres of blow-out were found over the entire area per acre of accumulation, except on hard land lying in the drier zones where it ran above 20 acres to 1.

The movement of sandy soils was mostly within the locality, gouging out some places and piling up the sand in others. Only the finely divided particles of the sandy soils were taken high into the air and borne away into the distance.

The movement of hard-land soils, wherein a great tonnage of dust was carried clear away in suspension, left only the larger aggregates behind to travel along the surface after the fashion of sand and form hummocks or drifts about various obstructions. The lower ratios of blow-outs to accumulations for hard lands in the higher rainfall belts suggest better aggregation due to higher organic-matter content.

In both cases the productivity of the land was seriously reduced by the removal of organic fertility blown away. The value of deposits accumulated locally varied greatly depending on composition, the topography, and the aging of the material.

COMPARISON OF TILLAGE HAZARD BY SOIL GROUPS

Although the soil groups were not equally represented in all the sample areas, they were widely enough distributed for group comparisons except for 1 B, the deep heavy-textured wheatland on slopes of 2 to 5 percent. Most of this small acreage was found to have been put in cultivation recently.

Table 5 shows that the sandy soils, both A and B slopes, are most heavily damaged by wind erosion, the heavier soils on B slopes by water erosion. Of the new land plowed out during the last war boom, 29.7 percent was B slope.

Up to 1936 only 14.3 percent of the plowed land in these sample areas was B slope. The new plow-up makes only a 15.4-percent increase in crop lands. Therefore, the trend toward a relatively greater water-erosion hazard is small but definite.

TABLE 5.—*Summary of erosion conditions on plowed land by soil groups including all sample areas in which each appears*

Soil groups and slope classes in order of resistance to wind erosion	Percent of acreage			
	Severely wind eroded		Severely water eroded	
	to 1936	to 1947	to 1936	to 1947
	Percent	*Percent*	*Percent*	*Percent*
1 A	0. 03	0. 04	0	0. 50
2 A	9. 66	7. 40	0	0
4 A	6. 35	8. 69	0	. 07
3 A	10. 40	12. 40	0	5. 00
5 A	39. 62	49. 75	0	1. 22
1 B	0	0	0	0
2 B	. 30	2. 67	23. 67	35. 00
4 B	14. 55	22. 78	2. 37	13. 00
5 B	35. 67	45. 78	. 44	1. 89
6 B	95. 00	98. 00	0	0

THE NEW LANDS

The acreage of new land plowed during the 1940's has been about double the net abandonment to 1947. The abandonment of new land, which appears to be inevitable on the basis of previous experience, would be 25 percent. This compares with a loss of 19 percent of the old plow-up to 1947.

Table 6 gives the amounts of old and new plowings by sample areas with the distribution of land-capability classes as described in table 3. In Baca County, Colo., alone, the proportion of lands unsuitable for cultivation in the new plow-up has been less than it was previous to 1936. In all the other sample areas relatively more poor land has been plowed recently than heretofore.

TABLE 6.—*Classes of land put in cultivation before and after 1936*

Sample area	Time of first plowing	Area	Class II	Class III	Class IV	Class VI and VII
		Acres	*Percent*	*Percent*	*Percent*	*Percent*
West Baca County, Colo.	Before 1936	244, 060	------	------	41. 4	58. 6
	After 1936	66, 250	------	------	56. 3	43. 7
East Baca County, Colo.	Before 1936	184, 940	7. 9	20. 5	62. 6	9. 0
	After 1936	70, 240	10. 2	11. 2	69. 9	8. 7
Hamilton County, Kans.	Before 1936	212, 670	27. 0	2. 1	59. 5	11. 4
	After 1936	55, 940	26. 6	. 4	59. 9	14. 1
West Texas County, Okla.	Before 1936	255, 720	56. 8	29. 7	0	13. 5
	After 1936	26, 460	48. 2	24. 1	0	27. 7
Morton County, Kans.	Before 1936	155, 340	79. 9	2. 2	5. 8	12. 1
	After 1936	20, 140	80. 0	2. 1	3. 2	14. 7
Stevens County, Kans.	Before 1936	148, 780	55. 9	17. 3	0	26. 8
	After 1936	11, 510	16. 9	9. 8	0	73. 3
East Texas County, Okla.	Before 1936	209, 840	47. 9	37. 6	0	14. 5
	After 1936	3, 620	41. 4	24. 3	0	34. 3
Seward County, Kans.	Before 1936	142, 340	92. 3	0	2. 9	4. 8
	After 1936	1, 580	20. 3	0	25. 3	54. 4
North Beaver County, Okla.	Before 1936	138, 900	71. 2	0	24. 4	4. 4
	After 1936	3, 300	14. 6	0	82. 1	3. 3
Total	Before 1936	1, 692, 590	44. 6	13. 4	23. 1	18. 9
	After 1936	259, 040	21. 3	6. 5	47. 5	24. 7

Keeping in mind that the acreage of new land is greatest in the western part of this territory, another notable fact is the concentration of class IV lands selected for cultivation in the low rainfall zones. This classification places 119,840 acres of the 123,040 acres of class IV land lately brought into cultivation in areas of less than 17 inches average annual rainfall.

It is also of interest that the plowing of land in the sample areas which took place as a result of World War II will probably add about the same acreage within these sample areas to permanent abandonment as did World War I, or roughly in the neighborhood of 120,000 acres.

It might be abruptly concluded that landowners are slow to learn about the capability of their lands. Before jumping to that conclusion, however, it would be better to consider some of the other possible meanings of the present developments. Obviously they indicate that the supply of good new land has become very scarce. This is especially true in the older settled counties like Beaver and Seward. Though small acreages were broken, the land was mostly of low capability because there was none better to be found unplowed.

More disturbing than this is the fact that large acreages of medium-grade land, class IV, were plowed without plans to safeguard its use for future temporary cultivation. The owners were willing to risk the long-time usefulness of marginal soils in order to make the quick profits derived from wearing off the new while prices were high.

The main hazard of temporary use in wind-erosion areas will probably always be that crop production will be carried to the point of actual loss of soil stability on land that should be retired to a sod crop while it is still stable and undamaged. In the drier areas, it may often be necessary to make the change when precipitation is favorable. Where such use leads to the sudden break-down of soil structure and the complete loss of wind-erosion control, it is doubtful that it will prove wise in the long run. In fact, experience would point to class VI as the proper rating of lands that get out of control too quickly.

On the other hand, where real possibilities of temporary use exist without undue hazards, the conservationist has an important job of program adaptation and application ahead of him. First, he must be sure that he makes a classification that will prove correct in future experience. Then, because of the nature of the risks, he should make a decisive separation of practical and impractical uses for class IV lands in the arid zone.

Temporary cultivation is not a problem in the arid zone only. Table 6 shows that class IV lands have been devoted to crop production in the semiarid territory as well. Such lands are not limited to temporary use for the same reasons in the semiarid zone as in the arid zone, but they are just as likely to fail in one place as the other.

A possible safety factor might be to understand more fully what has happened to those lands that have been damaged through cultivation to the point of permanent abandonment.

THE FATE OF ABANDONED LAND

An inventory of abandoned lands, other than those purchased by the Government and reseeded to grasses, shows that farmers reclaimed the slightly damaged lands very readily. However, severe erosion caused owners to prefer to keep 122,570 acres idle during the war boom of the 1940's. Much of this land was abandoned before 1936, but some of it went to the bad later. None of it contributed a respectable share of the war production.

The data given in table 7 show the stages of revegetation and the nature of the continuing erosion on abandoned lands. The most recent abandonment has evidently taken place in the eastern parts of Baca County, Colo., and Texas County, Okla. This is indicated by the large fraction of the land that has not recovered past the stage of annuals and weeds. In such localities the extent of continued soil accumulations far exceeds that of dispersions of the old hummocks and drifts.

Dispersion would not be expected to become extensive naturally until the decay of the vegetative structure upon which the accumulation was built allowed the wind to blow away drifts, hummocks, and in some cases even barrier accumulations. If dispersions took place on a greater scale than accumulations, a rather mature condition of abandonment was indicated. This was the case in West Baca, West Texas, Stevens, and North Beaver Counties, where generally one-half or more of the permanently abandoned land had acquired vegetation of the drop-seed association or beyond.

The effects of rainfall on the speed of revegetation can also be seen in these data. Slower progress in going from the weed stage to the drop-seed stage was marked in the areas of lower rainfall. The discouraging thing about the state of abandoned lands is that only 17.8 percent of them have so far come back into a condition of partial usefulness. The long periods of idleness after abandonment are costly consequences of overtaxing the capability of land.

TABLE 7.—*Natural revegetation and erosion on 122,570 acres of permanently abandoned land*

Sample areas	Percent of plowed acreage abandoned	Percent of abandoned acreage with—				
		Annual weeds	Drop-seed	Good perennials	Continued	
					Accumulations	Dispersions
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
West Baca County, Colo	19. 8	56	20	24	4. 1	5. 6
East Baca County, Colo	3. 5	93	6	1	15. 5	1. 7
Hamilton County, Kans	2. 2	45	18	37	30. 4	14. 8
West Texas County, Okla	3. 0	52	30	18	7. 0	24. 7
Morton County, Kans	3. 3	34	62	4	30. 6	7. 0
Stevens County, Kans	3. 5	33	56	11	5. 2	13. 4
East Texas County, Okla	3. 8	89	6	5	15. 0	0
Seward County, Kans	. 4	4	57	39	23. 0	0
North Beaver County, Okla	7. 5	43	47	10	. 2	2. 8
Weighted averages	5. 7	54. 7	27. 5	17. 8	8. 2	7. 2

DISCUSSION

From these studies it is clear that the practice of temporary cultivation of marginal soils along the arid fringes of the southern High Plains is just as prevalent as ever. Two things are wrong with it. First, class IV lands were kept in cultivation too long. Second, cultivation has been extended to poorer lands not capable of responding to such treatment, lands which should be placed in land-capability class VI.

In both cases the result has been excessive damage to the land, damage in some places so great that repair is too costly or is utterly impossible. It is most important to prevent rash attempts at farming the class VI lands and to install a better regulated system of temporary use on the real class IV lands. The lines drawn between class IV and class VI lands are the most important distinctions that can be made in capability so far as the highly vulnerable marginal parts of the wind-erosion areas are concerned.

Economic or patriotic justification can be argued for wearing the new off the class IV lands during periods of great demand, but there is no possible justification for destroying the long-time usefulness of either class VI or class IV lands by overuse. The latter course may be considered neither patriotic nor economic.

Organic fertility and physical structure must both be renewed at appropriate intervals in class IV lands to compensate for the naturally rapid rate of deterioration these soils undergo when put in cultivation. Otherwise they will quickly become class VI or even class VII lands. The only means now known for effectively renewing productivity to maintain such lands at a satisfactory level is the use of soil-building crops with rest periods. It is highly important to cease cultivation before the soil structure breaks down to a stage beyond control, so that the sod cover can be regained while the soil is still stable and moisture conditions are favorable.

A field of class IV land capability thus managed, may safely enter a period of restoration in preparation for the next emergency need, rather than lie idle as the damaged lands of the 1930's did during World War II.

A speculative attitude on the part of operators seems to make this use of middle-grade lands particularly difficult. The idea of plowing the land for a planned program of temporary crop production to be followed by a definite system of restoration has not become widely accepted. Too much of the marginal land has been plowed without thought of its protection. The land is expected to go wild sooner or later at which time operations will be abandoned. This procedure is not at all necessary on class IV lands. It is flagrantly destructive. Failing in the timely retirement of marginal lands is just as much to be deplored as breaking out submarginal lands.

SUMMARY

The limitations of land must be recognized clearly before good judgment in land use choices can be used. For the areas represented in this study they may be summarized as follows:

Experience has proved that shallow, moderately sandy and deep, loose sand-hill soils of gentle slope or steeper cannot be kept productive under cultivation anywhere in the 14- to 20-inch rainfall belt.

Shallow-depth hard lands, both flat and sloping, have failed in all areas of less than 18 inches average rainfall. Nearly level medium-depth moderately sandy lands, on the other hand, stood up well with suitable practices under rainfall as low as 16 inches.

Medium-depth hard lands have a fair to good record of performance throughout the territory sampled, but below 17 inches of rainfall a program of alternate cultivation and restoration under sod would be required to avoid the unbearable losses sustained heretofore. This brings out the question as to how long class IV lands may be safely kept in cultivation. Experience indicates that the hard lands of this class go into an unmanageable condition somewhat more slowly than the sandy lands.

In any event the signs of overuse, such as difficulty of maintaining crop residues and difficulty of getting crop stands, should be promptly heeded. The length of safe periods of cultivation must necessarily vary both with soils and with climatic conditions. Deep loamy sands with 18 to 20 inches of rainfall offer fair possibilities of maintaining fertility and stability against wind erosion by the use of manure crops in the rotation.

Deep, nearly level hard lands, the best of the High Plains wheat soils, can be farmed with appropriate precautions wherever found. But in this study they do not occur in sample areas having less than 16 to 18 inches of rainfall.

At the same time, the cost of indulging in careless mistakes, which induce serious wind erosion unnecessarily on good lands, has been shown to be astonishingly high. Factors that indicate the decline of productivity of wheatlands, derived from more than 100 records, are summarized in table 8. These results show that the productivity of high-capability lands can be as seriously affected by topsoil removal as that of low-capability lands.

Table 8.—*Wheat yields on lands of the southern Great Plains with varying wind-erosion removals (Preliminary, 1947)* [1]

Degree of erosion	Wheat yields per acre on—		
	Flat deep heavy soils, class II		Rolling shallow heavy soils, class IV
	Summer fallowed	Continuously cropped	Continuously cropped
	Bushels	*Bushels*	*Bushels*
Slight	45. 0	29. 0	22. 0
Moderate	33. 0	27. 2	15. 0
Severe	26. 2	17. 6	13. 5

[1] Studies of the effects of wind- and water-erosion removals on wheat yields in the southern High Plains are under way. This investigation includes 912 production records on lands rating capability classes II, III, IV, and VI, during the period 1945–48.

Special attention should be given quickly to the gently sloping lands already under cultivation in areas subject to water erosion, that is to say, those having anywhere above 17 inches average rainfall. If these lands are to be saved from abandonment, terracing with contour farming is imperative. Specifically, these practices apply to medium-depth gently rolling hard lands of which there were 86,760 acres in cultivation in the 20-county area of the Joel survey. The same urgency applies to the shallow, gently rolling, moderately sandy lands, but in this case permanent retirement to grass is the thing needed. Until recently 222,500 acres of these soils were being farmed.

No new sloping hard lands should be brought under the plow for cultivation on either a temporary or permanent basis without the protection of terracing and contour tillage. Otherwise they are just as sure to be put out of production by water erosion as are the low-capability lands of the arid belt by wind erosion.

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